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ABSTRACT:

In an electrodynamically damped stepping motor with a permanently excited rotor, the rotor possesses, on one end face, magnetic zones 4 of alternating polarity, these zones interacting with a conductive reaction disc 12, 13 which is immovably located in the stator. The motor is employed in the digital processing of information for control and positioning functions. <IMAGE>

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(54) **Electrodynamically damped stepping motor**

(57) In an electrodynamically damped stepping motor with a permanently excited rotor, the rotor possesses, on one end face, magnetic zones 4 of alternating polarity, these zones interacting with a conductive reaction disc 12, 13 which is immovably located in the stator. The motor is employed in the digital processing of information for control and positioning functions.

Fig. 1

Fig. 2

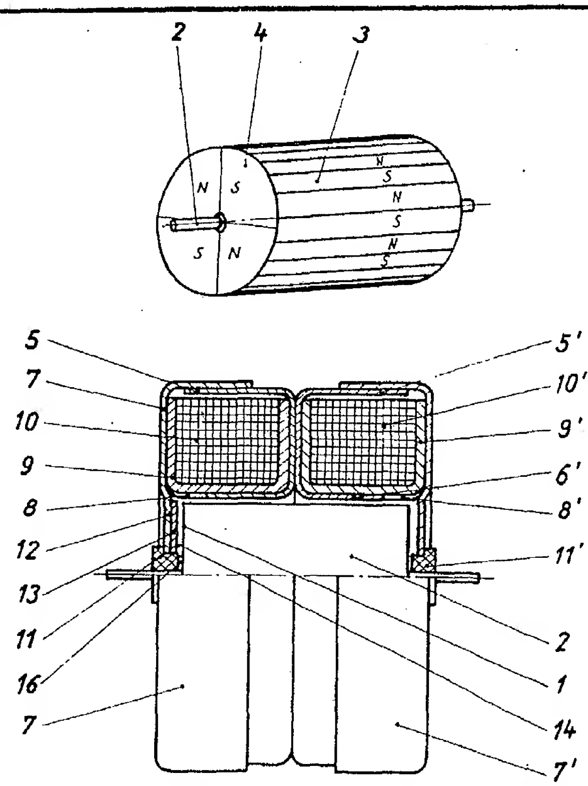

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Fig. 1

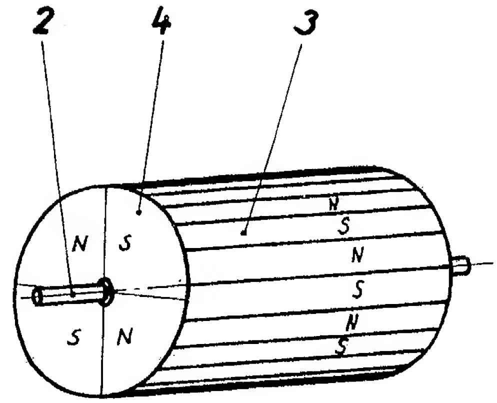
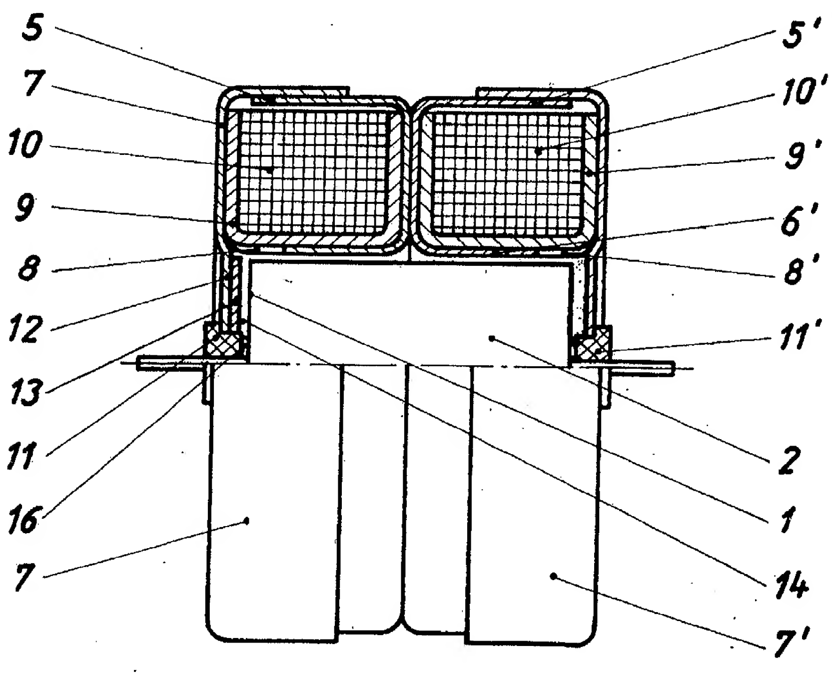


Fig. 2



SPECIFICATION

Electrodynamically damped stepping motor

The invention relates to a stepping motor with an electrodynamic arrangement for damping the movement of the rotor, especially for stepping motors having a permanently excited rotor.

Stepping motors possess a rotor which rotates intermittently, and which rotates in a stepwise manner, in accordance with the pulses which are supplied to the operating winding, the rotor coming more or less to rest after each step. In order to ensure that the motor operates reliably, it is necessary that it carries out each step in a precise manner, within its operating parameters. In order, at the same time, to obtain high stepping frequencies and torques, it is necessary to damp the electromechanical system. Various arrangements have been disclosed for this purpose. According to German Auslegeschrift 1,488,654 and German Offenlegungsschrift 2,108,001, and IPK H 02 K, 37/00, the damping action is obtained by filling the casing of the stepping motor with fluid of a definite viscosity, this fluid damping the rotary movement of the rotor by fluid friction. A similar proposal is submitted in DDR Patent Application 59,311, DPK 21 d[1], 19, according to which the stepping motor is likewise filled with liquid, or is coupled to a fluid-filled rotation system.

The disadvantages of these types of arrangement for damping stepping motors reside especially in the technological problems involved with the manufacture of casings and bearings which are leakproof with respect to liquids, as well as in the need to achieve constant operating temperatures, since the viscosity of the liquids, and hence their damping properties, change with the temperature.

Further arrangements for damping the electromechanical system of stepping motors involve the provision, as described in German Offenlegungsschrift 1,538,962, of additional flywheel masses on the rotor, which can rotate freely and which are coupled to the rotor by means of mechanical friction-type couplings, or fluid-type couplings. Arrangements of this type are very expensive to manufacture.

According to German Offenlegungsschrift 2,136,531, IPK H 02 K, 37/00, a layer of a good electrical conductor is located on the rotor of a stepping motor. The operating flux induces eddy currents in this layer, which act on the movement of the rotor, with a damping effect. The eddy currents, induced in this layer, accordingly act only for the time during which an operating flux is present. At the same time, the disadvantage arises that the operating flux is damped, and the efficiency consequently deteriorates.

Finally, DDR Patent Application 59,911 discloses the damping of rotors by means of mechanical friction-pieces. The frictional torque, which is virtually independent of the speed of rotation, has an unfavourable effect on the starting behaviour of the stepping motors and limits their useful life.

The same patent specification describes the damping of stepping motors by means of eddy current brakes. To do this, a copper disc rotates in the electromagnetic field and gives rise to a damping effect which is proportional to the speed of rotation. However, the moment of inertia of the stepping motor is considerably affected by the size of the eddy current damper needed for the required damping effect, and is difficult to fit in, especially if the component dimensions are small.

An object of the invention consists in reducing the expense involved in the manufacture of electrodynamically damped stepping motors, and in improving their efficiency.

The object underlying the invention is to produce an electrodynamically damped stepping motor, possessing a stator which has an electrically excited pole, and possessing a rotor with poles which are located at the periphery, in particular a permanently excited rotor, this stepping motor containing an electrodynamic damping device which is easy to manufacture and which acts in proportion to the speed of rotation, and which guarantees a high efficiency and a long useful life, accompanied by a small overall volume. At the same time, the intention is to avoid increasing the angular momentus of the rotating system as far as possible.

The object of the invention is achieved in that the rotor possesses, at least on one end face, magnetic zones of alternating polarity, and in that, parallel thereto, an electrically or electrically and magnetically conductive reaction disc is located in the stator, in a manner preventing rotation, and separated from the rotor by an axial air gap.

In order to reduce the expense of manufacture, it is expedient to design the reaction disc as a portion of the motor casing. In doing so, it is advantageous to design the reaction disc to be made from the same electrically conductive, magnetically soft material, used for the motor casing.

In this most simple embodiment of the invention, the damped stepping motor possesses no additional component in comparison with the undamped motor, since the functional elements of the damping device are integrated into the structural elements of the stepping motor. The only additional expense necessary is the magnetisation which must be carried out on the end face of the rotor.

The eddy currents which are induced in the electrically conductive, magnetically soft reaction disc, generate a damping torque, the necessary magnitude of the induction being obtained due to the fact that the reaction disc simultaneously ensures the low magnetic resistance which is necessary in order to conduct a high magnetic flux.

The axial tension forces which occur between the rotor and the reaction disc, acting jointly with a spacing washer, ensure the constant air gap which is necessary for a reproducible damping effect, without any need for rigorous tolerance

requirements in respect of the axial bearing play, or for other design measures having the same effect.

In order to match the damping characteristics to the operating curve of the stepping motor and, at the same time, to optimise the axial bearing forces, the reaction disc is composed, in one embodiment of the invention, of two layers, of which the layer facing the rotor is composed of an electrically conductive non-magnetic material, and the layer facing away from the rotor is composed of a magnetically soft material.

In a special version of this design, the electrically conductive non-magnetic layer amounts to 30—70% of the total thickness of the reaction disc, the magnetically soft layer being designed to be no thicker than necessary for conducting the flux.

While, if the reaction disc is designed to be composed of an electrically conductive, magnetically soft material, there is a proportionally constant relationship between the damping torque generated by the eddy currents (referred to a constant speed of rotation) and the axial tension force, the damping torque can be selected, within wide limits and independently of the axial tension force, if the reaction disc is made from two layers, as described above. By this means, the axial load on the bearings is considerably reduced, despite a possible increase in the damping torque, and the useful life of the stepping motor can be increased.

If a permanent magnet having very high field strengths, greater, for example, than 1,500 A cm^{-1}, is available for the rotor of the stepping motor, an electrically conductive non-magnetic material suffices for the reaction disc. In this case, since no axial tension forces are present, other design measures must be provided in order to obtain a constant air gap.

Reference is now made to the accompanying drawings, in which:—

Figure 1 shows a perspective view of a permanently excited rotor; and

Figure 2 shows a half-section through the stepping motor according to the invention.

The rotor 1, illustrated in Figure 1, is composed of a cylindrical magnetic body, sixteen poles 3 being arranged, in alternating pole-sequences, on its periphery, and four magnetised zones 4 being arranged, in alternating pole-sequence, on one end face, this magnetic body being attached to a shaft 2.

In Figure 2, a magnetised rotor 1, of the type according to Figure 1, is located inside the stator of a stepping motor. The stator possesses two inner casing shells 5 and 5′, which are manufactured from magnetically soft deep-drawing sheet and are attached to each other, each shell having eight claw poles 6 and 6′, which are located in two outer casing shells 7 and 7′, made from the same material. Each of the outer casing shells 7 and 7′ possess eight claw poles, 8 and 8′, which are centrally positioned in the gaps between two claw poles 6 or 6′.

The claw poles 6 and 6′, and 8 and 8′ are mutually displaced by half a claw-pole spacing. The operating windings 10 and 10′ are located, on coil formers 9 and 9′, inside the casing shells 5 and 5′, and 7 and 7′. The bearings 11 and 11′ for the shaft 2 of the rotor 1 are located inside the outer casing shells 7 and 7′. The annular zone 12 of an outer casing shell 7, adjoining the bearing 11, is attached to an aluminium disc 13, in a manner preventing rotation. The annular zone 12 and the aluminium disc 13 together form the reaction disc which interacts with the magnetised zones 4 of the end faces 14 of the rotor 1. In order to ensure that the axial air gap 15 remains constant, a spacing washer 16 is located between the bearing 11 and the end face 14 of the rotor 1, this washer being made of a low-friction material.

The ratio of the thicknesses of the deep-drawing sheet in the annular zone 12 and of the aluminium disc 13 is chosen to be 1:1, this ratio resulting in an optimally adjusted operating curve for the stepping motor in question.

Claims

1. Electrodynamically damped stepping motor possessing a stator which has an electrically excited pole, and possessing a rotor with poles which are located at the periphery, in particular a permanently excited rotor, characterised in that the rotor (1) possesses, at least on one end face, magnetic zones of alternating polarity, and in that, parallel thereto, an electrically or electrically and magnetically conductive reaction disc is located in the stator, in a manner preventing rotation, and separated from the rotor by an axial air gap.

2. Electrodynamically damped stepping motor according to Claim 1, characterised in that the reaction disc is a portion of the motor casing.

3. Electrodynamically damped stepping motor according to Claim 1 or 2, characterised in that the reaction disc is composed of an electrically conductive magnetically soft material.

4. Electrodynamically damped stepping motor according to Claim 1 or 2, characterised in that the reaction disc possesses two layers, of which the layer facing the rotor is composed of an electrically conductive non-magnetic material, and the layer facing away from the rotor is composed of a magnetically soft material.

5. Electrodynamically damped stepping motor according to Claim 4, characterised in that the layer composed of an electrically conductive non-magnetic material amounts to 30—70% of the total thickness of the reaction disc, the magnetically soft layer being designed to be no thicker than necessary for conducting the flux.

6. Electrodynamically damped stepping motor

according to Claim 1 or 2, characterised in that the reaction disc is composed of an electrically conductive material.

7. Electrodynamically damped stepping motor substantially as described with reference to and as illustrated in the accompanying drawings.

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